Special Topics in Data Assimilation

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Description:
Data assimilation in oceanic and atmospheric circulation models, as well as in other simple models is discussed. Topics include function fitting through the least-squares approximation, nudging, penalty functionals, representers, optimization, the initialization problem, ‘weak’ and ‘strong’ constraints, error covariance, and Kalman filters. This course is based heavily in computational methods for optimizing model predictions. Therefore a computer lab is included that will focus on numerical techniques often used in data assimilation; the classroom (three credits) and lab (one credit) portions of this class are tightly linked, and need to be taken concurrently.

Course Outline:
Week 1:
Class: Review of statistics.
Lab: Introduction to the python programing language.

Week 2:
Class: Bayesian analysis and model development.
Lab: Arrays (numpy) and plotting (matplotlib) in python.

Week 3:
Class: Function fitting and the least squares approximation.
Lab: Numerical tools and challenges for least squares analysis.

Week 4-6:
Class: Adjoints and Lagrange multipliers, penalty functionals, representers, ‘weak’ and ‘strong’ constraints.
Lab: Simple forward, tangent-linear, and adjoint models based on the transport and KvD equations.

Week 7-9:
Class: Practical optimization methods, estimating the error covariance matrix, data nudging, the Kalman filter.
Lab: Kalman filters and ensemble Kalman filters for the transport and KvD equations.

Week 10-13:
Class: Literature review – examples of data assimilation (paper choices based on student interests).
Lab: Building an adjoint model from source code.

Week 14-15:
Class: Student project discussion
Lab: ditto
Prerequisites:
Knowledge of basic statistics and programming skills (we will use python, but FORTRAN or MATLAB skills will be sufficient). OCNG 657, STAT 601, or instructor permission.

Grading:
Homework will be assigned for each of the broad topics, and will primarily involve computer program modification discussed in the lab. Homework will account for 50% of your final grade. Also, students will be expected to contribute to, and occasionally lead, discussions of scientific papers, accounting for 10% of your grade. A research project, for example consisting of a small program implementing some data assimilation method, with an accompanying in class demonstration, will account for the remaining 40% of your grade. The grading scale is 90-100% = A, 80-89% = B, 70-79% = C, etc.

Text:
There will be no text for this class. Excerpts will be taken from these and other books and papers:
• Atmospheric Data Analysis, by Roger Daley
• Inverse Modeling of the Ocean and Atmosphere, by Andrew F. Bennett
• Bayesian Forecasting and Dynamic Models by Mike West and Jeff Harrison

Plagiarism. As commonly defined, plagiarism consists of passing off as ones own the ideas, words, writings, etc., which belong to another. In accordance with this definition, you are committing plagiarism if you copy the work of another person and turn it in as your own, even is you should have the permission of that person. Plagiarism is one of the worst academic sins, for the plagiarist destroys the trust among colleagues without with research cannot be safely communicated. If you have any questions regarding plagiarism, please consult the latest issue of the Texas A&M University Students Rules, student-rules.tamu.edu, under the section ‘Scholastic Dishonesty.’

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